THE IMPACT OF URBAN OPERATIONS ON HELICOPTER NOISE REQUIREMENTS

Stanley R. Spector
Hughes Helicopters

SUMMARY

The national state of urban transportation, vis-a-vis traffic congestion and extended travel time, has generated a need for solutions to improved urban mobility. The helicopter is one of the solutions for alleviating this problem, lending itself naturally to the urban setting through its vertical lift operation. The helicopter is a necessary urban transport by virtue of its ability to perform unique public safety missions as well as its potential contribution to the economic well-being of the city. The helicopter will be to the city's economic development what the fixed-wing aircraft is to the nation's economic development. The helicopter will do the same job as the fixed-wing aircraft, only over shorter distances.

However, the role of the helicopter in the city has been severely limited by the public resistance to helicopter noise and concern for operating safety. This has resulted in the adoption of noise regulations which can severely restrict helicopter operations near residential areas, even in the middle of urban commercial and industrial zones. The consequence has been a lack of public heliport development necessary for the expansion of urban helicopter operations.

These factors dictate the need for adoption of quiet helicopter operating techniques and the industry-wide development of helicopter quieting improvements. Unless and until this is achieved, industry growth will not reach its full potential.

INTRODUCTION

While the helicopter industry has enjoyed considerable growth in the last 10 years, the executive transport segment of the market has had a limited growth due to restricted operations in major metropolitan centers of the world. This is the result of public resistance to urban helicopter operations because of the concern for safety and noise over the city. It has had a negative impact on the establishment of public-use heliports within the city. These factors along with helicopter productivity and operating cost are the primary factors affecting the helicopter industry growth, specifically in expansion of the executive market in urban operations.

This paper focuses on the interrelationship of urban helicopter operations, helicopter noise, and the establishment of urban public-use heliports. The impact of these factors on industry growth dictates the need for government and industry effort to reduce helicopter noise.

URBAN HELICOPTER TRANSPORTATION REQUIREMENTS

The most recognized importance of helicopters today by the general public is in public safety applications such as law enforcement patrol, fire fighting, and emergency rescue. Most citizens are aware of the role the helicopter plays in emergency situations and have come to rely on it for this purpose, particularly in the city. Many surveys by city law enforcement agencies have shown that over 90 percent of the public support the continuation of urban law enforcement patrol, for example. However, such acceptance has been accompanied by many noise complaints during orbiting operations at 153 meters (500 feet), prompting law enforcement agencies' interest in quieter helicopters.

A less understood but equally vital role of the helicopter is in providing transportation for urban business and industry who support the local economies through employment and taxes. The continuation and growth of helicopter operations in the city will assure a city's economic viability and growth. This will be achieved through the future development of intercity helicopter transport such as helicabs, helibuses and helitrucks as a means of offsetting the declining mobility in megalopolitan areas. However, this growth in urban helicopter transportation and the future economy of the cities can take place only if there are public heliports which can be used economically. Support for these relationships can be found by examining the impact of air transportation on national economic development. Previous studies (ref. 1) have shown that there is a correlation between air travel and business development nationally. This correlation can be related to the city because the population and employment continue to increase in the city's metropolitan rings resulting in increased travel distances and travel times. As in the national case, more rapid and convenient mobility is needed to facilitate commerce.

Specifically, the population growth in 24 of the largest cities' metropolitan rings is expected to increase at the rate of 6 million people per year between now and 1985 (ref. 2) as shown in figure 1. Conversely, central cities' population will remain relatively constant.

The same pattern is reflected in employment growth where there is a significantly greater rise in total employment in the city metropolitan rings as compared with that in the central cities, as shown in figure 2. These patterns reflect a clear decentralization of business and population around metropolitan areas. Furthermore, it is found (ref. 3) that transit usage does not stem the tide of decentralization of population and employment from the central city. In fact, central cities with the highest transit usage consistently exhibit the smallest increases or the largest declines in employment and population in both their central cities and metropolitan rings. In addition, the latest census shows that commuters in 21 of the largest metropolitan areas are abandoning public transit at the average rate of 0.7 percent per year in favor of their cars, which means more traffic congestion. Yet, massive emphasis is being put on rapid transit servicing central cities to the exclusion of alternate modes of transportation that could provide rapid service between business enterprises in the metropolitan rings.

Decentralization results in an increase in distance between companies doing business with each other in the city's metropolitan rings and the central city. This requires a transportation system to service the business, industry, and others who have the need to travel around the city in a fast, safe, convenient, low-cost transportation system not impeded by surface congestion. The helicopter fills these requirements and in addition requires a relatively small investment and a minimum of premium land. Helicopter transportation will help prevent the erosion of central city business and help assure a sound growth of business and industry in the city's metropolitan rings.

Four- to five-place light helicopters now provide business transportation within the city. This application will grow in the coming years with the achievement of competitive operating cost compared to taxis in the 1980's and up to two times faster helicopter delivery for 32-kilometer (20-mile) trips. The light helicopter is also capable of providing 454-kilogram (1/2-ton) freight transport now. This application will also grow in the coming years with the achievement of competitive operating costs compared to 454-kilogram (half-ton) trucks in the 1980's and up to 3 to 12 times faster helicopter delivery for 320-kilometer (200-mile) trips.

An analysis of the growth in the U.S. helicopter fleet and expected flying hours shown in figure 3, indicates a potential threefold growth in urban operations by 1985, contingent upon acceptance of helicopters in the city. This will depend on helicopter quieting and heliport availability. The continued economical operation and growth of helicopter utilization in the city will encourage the economic growth that is under way in the urban area outside 24 of the largest central cities. The availability of fast helicopter transportation will contribute to the establishment of new industries. The 250,000 new jobs per year previously cited in manufacturing, trade, and selected services represent an increase in local income for the cities of $100 billion over a 20-year period.

Noise Constraints

With the emphasis throughout the United States on noise suppression and control, by law, the U.S. Environmental Protection Agency has imposed requirements on all levels of government to improve the quality of the environment. This has resulted in some aggressive and imaginatively new noise standards. One standard of noise that has been considered by some governments is a calculated value. It is an integration of the measured sound level and exposure time that results in a maximum day-night noise level requirement (Ldn) at property lines of residential areas. The sound level is measured in decibels on an "A" weighted scale (dBA) which reflects the way the human ear responds to sound frequencies. Exposure time is a function of the number of flights, duration, and the hour of day that the sound occurs. The result of this new measurement standard is an average hourly noise level which permits a tradeoff of time integrated sound levels with the number of flights in a 24-hour period to achieve a balance with the noise level requirements. In the state of California, the maximum average hourly noise level is 65 dB Ldn for new heliports.

The equation for this noise standard is as follows:

$$\mathrm{Ldn} = 10\,\mathrm{LOG}\left[\frac{15}{24}\,\Sigma\,\mathrm{ANTILOG}\,\frac{\left(\mathrm{HNL}_{\mathrm{DAY}}\right)}{10} + 10\left(\frac{9}{24}\right)\Sigma\,\mathrm{ANTILOG}\,\frac{\left(\mathrm{HNL}_{\mathrm{NIGHT}}\right)}{10}\right]$$

$$\mathrm{HNL} = 10\,\mathrm{LOG}\left\{\sum_{\mathrm{TAKEOFF}}\left[\left(\mathrm{ANTILOG}\,\frac{\mathrm{dBA}}{10}\right)\times\Delta t\right] + \sum_{\mathrm{LANDING}}\left[\left(\mathrm{ANTILOG}\,\frac{\mathrm{dBA}}{10}\right)\times\Delta t\right]\right\} - 35.6$$

The basic equation averages the hourly noise level for a 24-hour period. Night operations from 2200 hours to 0700 hours are penalized by a factor of 10 times compared to those flights between 0700 and 2200 hours. The noise event or the hourly noise level (HNL) is measured on the A-weighted scale and is integrated over the period of duration and the number of events. This computation is made for both landings and takeoffs and applies to noise above some ambient threshold level.

A similar measurement is the community noise equivalent level (CNEL). This breaks the evening into two intervals with two different weightings for a total of three intervals in a 24-hour period. CNEL measurements are within 1/2 dB of the Ldn measurements.

Operational Impact

The foregoing noise constraints limit the number of flight operations at a heliport depending on its location relative to an impacted residential area. In many cities, residential areas can be found in the middle of industrial and commercial zones. Notwithstanding the zoning use, residents are still protected under the law as is the case in the State of California. To understand the significance of this, an evaluation was made of the noise impact on urban helicopter operations from heliports in close proximity to residential areas.

A normal single-engine turbine helicopter takeoff, observing conventional height/velocity constraints would have a flight profile as shown in figure 4. A typical condition in a city like Los Angeles might find a residence within 244 meters (800 feet) of the takeoff and landing position. During takeoff, for the example shown, the helicopter might be required to fly over a residence where the helicopter would be 31 meters (100 feet) above the observer at the closest distance. With representative sound levels shown in figure 5, a light turbine helicopter would have as high as a 92 dBA sound level at the observer. The sound level time history of this takeoff and landing is shown in figure 6, where the daytime ambient is 65 dBA and the nighttime ambient is 50 dBA. These ambient conditions are typical for large cities.

Applying these results to the Ldn equation produces day-night average noise levels as shown in figure 7 for a range of light turbine helicopter operations. At the 65 dB Ldn regulation level, flights are restricted to approximately 1 per hour under the foregoing operating conditions. If heavy turbine helicopters are included in the operation as shown in figure 8, the combined operating limit is still approximately 1 flight per hour at 65 dB Ldn, but a little more restrictive at higher noise levels. These operations are severely limiting for a commercial downtown, public-use heliport while they are probably compatible with privately operated heliports in the same location.

If the observer's distance from the landing and takeoff point is doubled to 488 meters (1600 feet), then there is a fivefold improvement in the number of flights at 65 dB Ldn. On the other hand, if a vertical takeoff is executed with a light turbine helicopter, the permissible flight operations are doubled.

The impact of noise requirements on helicopter operations can also be seen by examining the noise footprints. Using 65 dB Ldn with a shallower 1:6 flight slope during daytime operations only, the resulting footprint is shown in figure 9. With the impact zone at 488 meters (1600 feet) from the takeoff point approximately 120 flights per day can be achieved. By increasing the maximum allowable noise level to 70 dB Ldn, the footprint shown in figure 10 is approximately one-half the size for the same number of flights.

Therefore, 65 dB Ldn is a restrictive requirement in terms of locating heliports in central cities or metropolitan rings where residential areas are within 305 meters (1000 feet) of the heliport under the flight path. As seen above, 70 dB Ldn gives the heliport planner less restriction in finding suitable locations.

However, there are alternatives for increasing helicopter operations rather than raising the regulated maximum noise level which regulatory groups are reluctant to do. The alternatives consist of noise reduction techniques which will be applied in the establishment of the first public-use heliport in the City of Los Angeles. The site selected is the top level of a parking structure adjacent to the Los Angeles Convention Center in the downtown area, shown in figure 11. Not far from the facility are residential buildings, potentially impacted; but the site was chosen because of its proximity to a major freeway with a daytime ambient of 66 dBA at the residence adjacent to the freeway, to the right of the picture. Freeways in Los Angeles are prescribed routes for helicopter operation at the option of the pilot. By observing several flight operation techniques shown in figure 12, noise impact is reduced. Approaches and takeoff/departures are executed over the freeway away from the residential area. Final approach and takeoff can be as steep as safely possible, with a high rate of climb during takeoff.

By following these procedures, approach sound levels for light turbine helicopters were reduced by 13 dBA and departures reduced by 19 dBA. However, even at the highest sound levels in this particular case, the light turbine helicopters could execute 10 flights per hour while flying over the residence using a steep slope path. The noise reduction techniques increased the number of permissible takeoffs and landings fivefold, to 50 per hour, far in excess of the flight operations actually expected at the heliport.

NOISE REDUCTION PROGRAMS

While the results in the Los Angeles public-use heliport case are favorable, the site location and operating techniques made the difference. Experiences in other cities are not always as favorable, nor is it favorable for many other desirable locations in Los Angeles. With regulatory control becoming ever tighter, there's a need for a concerted effort by Government and industry to develop and implement a noise reduction program for helicopters. The Federal Government and the helicopter industry have been working on noise reduction for the last 9 years on an irregular basis. Some of the technology for quieting helicopters became known in the Quiet Helicopter Program conducted by Hughes Helicopters in 1971 for the U.S. Advanced Research Projects Agency and the Eustis Directorate, U.S. Army Mobility Research and Development Laboratory. The product of that program was the Quiet One shown in figure 13. Up to a 90-percent reduction in sound level was achieved in an effort to find the limits of quieting. The program demonstrated that the helicopter can be the quietest of all aircraft when they are compared on the same basis. The economic reasonableness of all the quieting techniques was not determined, but the FAA is now investigating this. Some of the techniques used consist of muffling engine inlet and exhaust ports, reducing rotor speed, rotor blade aerodynamic redesign, and piloting procedures.

Approximately $5 million has been spent by the Federal Government and industry over the 9-year period to reduce helicopter noise. However, many times that amount has been spent to reduce engine noise for fixed-wing aircraft. It appears as if the time has come to put some increased effort on quieting helicopters. The FAA noise certification standards for helicopters, now being developed, will dictate this. Hughes, for example, is now in the process of implementing a four-bladed tail rotor with reduced tip speed in the 500D light turbine helicopter (fig. 14) which is expected to provide a substantial subjective noise reduction. Hughes already offers a quiet helicopter, its model 300CQ (fig. 15), which is an extension of its model 300C light piston helicopter. Both model 300's are used extensively in law enforcement patrol. The 300CQ has a dual muffler kit and is certificated to operate in a quiet mode at 93 percent of full engine RPM. At 80 km/hr (50 mph) patrol speed and 873 kilograms (1925 pounds) gross weight (921 kilograms (2030 pounds) is normal maximum with the quieting kit) the 300CQ provides a 12 dBA sound reduction and a 65 dBA overall sound pressure level at ground level during a 152-meter (500-foot) altitude flyover.

SUMMARY

Helicopter noise has brought government regulation. This has restricted heliport locations and operations in urban areas, specifically where residential areas are impacted. The importance of the helicopter in the city is increasing as alternate modes of transportation are required to offset the growing surface traffic congestion. Traffic congestion is a deterrent to future rejuvenation of the central city and the needed industrial expansion of cities' metropolitan rings. Helicopter noise must be reduced in order to encourage its increased use in the city. Until this is done, the growth of an important segment of future helicopter application is impaired.

In order to achieve the national goals for urban redevelopment and related transportation improvement, the government needs to include helicopter improvement and heliport design and construction in its national transportation plan. Specifically, a government/industry quieting development program is needed for all classes of helicopters, including the application of available engine quieting technology. The application of present and evolving technology will assure that helicopters will become an important adjunct to urban transportation and a good neighbor.

REFERENCES

1. Stuelpnagel, Thomas R., "The Helicopter is a Necessary Urban Transport for the 1980s," Verti-Flite, vol. 19, no. 2, Mar/Apr 1973, pp. 18-19, 22-23.

2. Ganz, Alexander, "Emerging Patterns of Urban Growth and Travel," Project Transportation, Massachusetts Institute of Technology (Cambridge, Mass. 1968). (Updated by S. R. Spector in 1976 from Department of Commerce data.)

3. Meyer, J. R.; Kain, J. F.; Wohl, M., "The Urban Transportation Problem," (Cambridge, Mass., Harvard University Press, 1971).

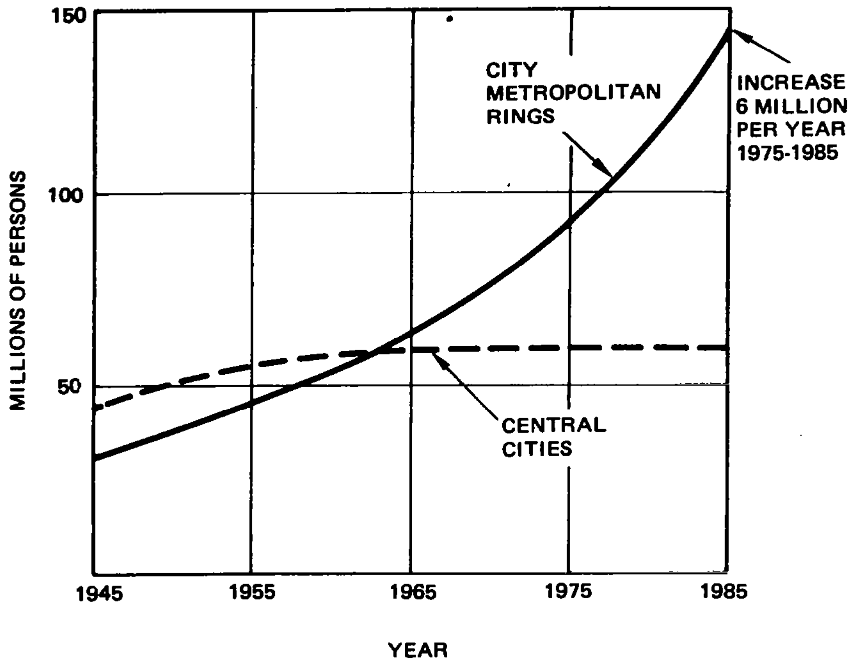

Figure 1.- Urban population growth. (From ref. 2.)

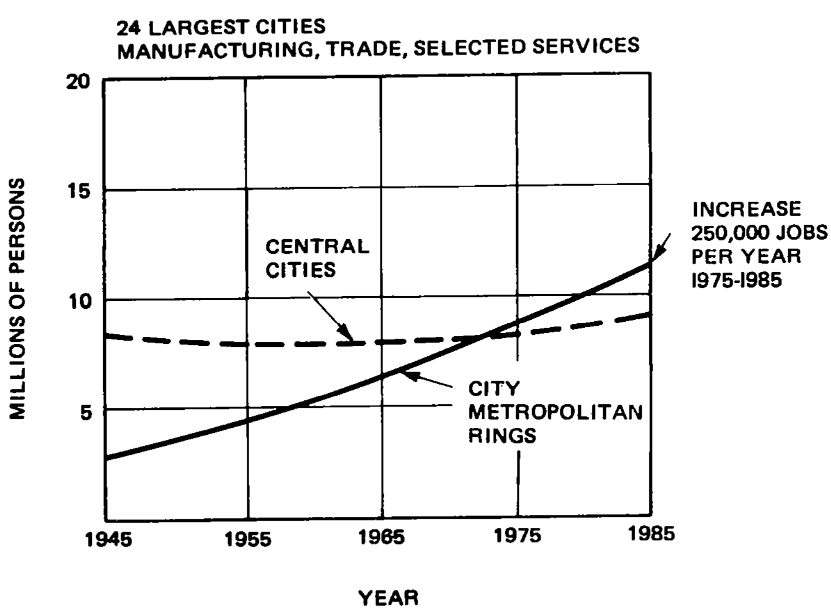

Figure 2.- Employment growth. (From ref. 2.)

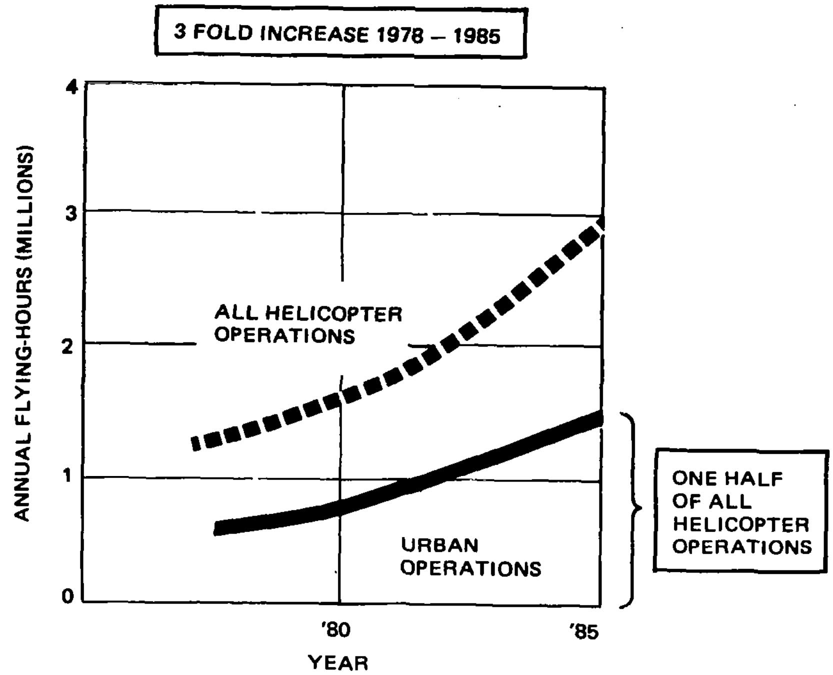

Figure 3.- Growth in U.S. urban operations.

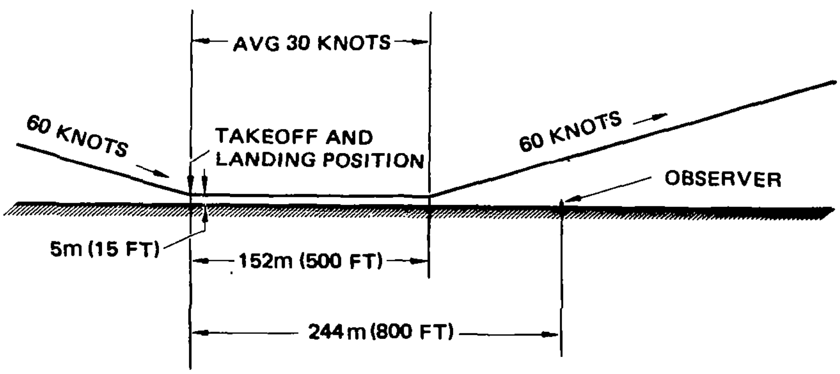

Figure 4.- Light turbine flight path - 1:3.5 slope.

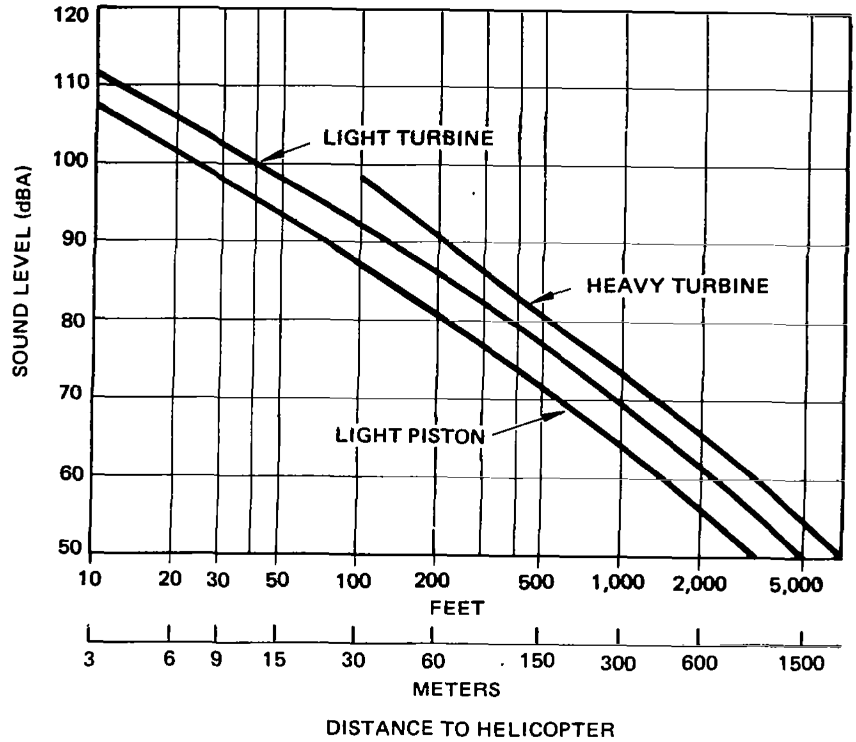

Figure 5.- Helicopter sound level.

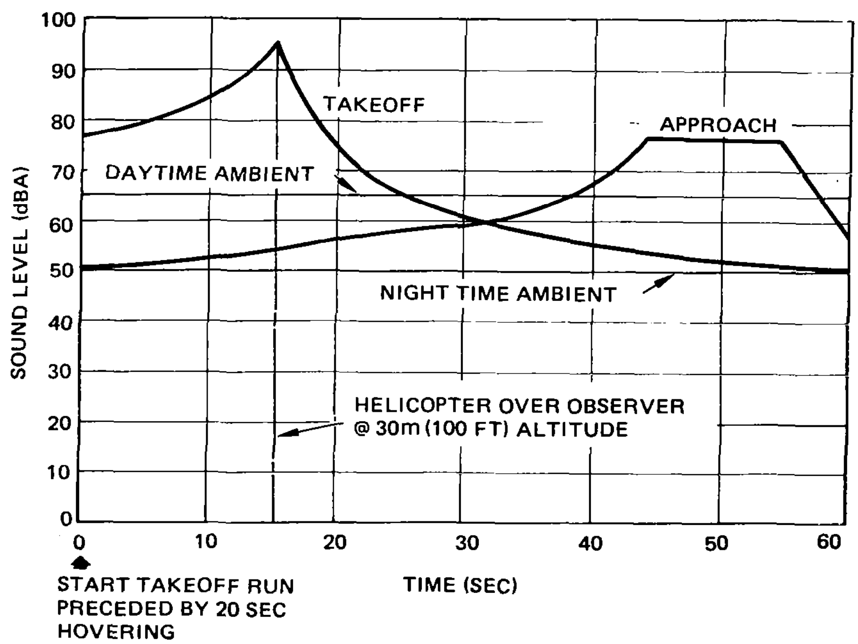

Figure 6.- Light turbine sound history.

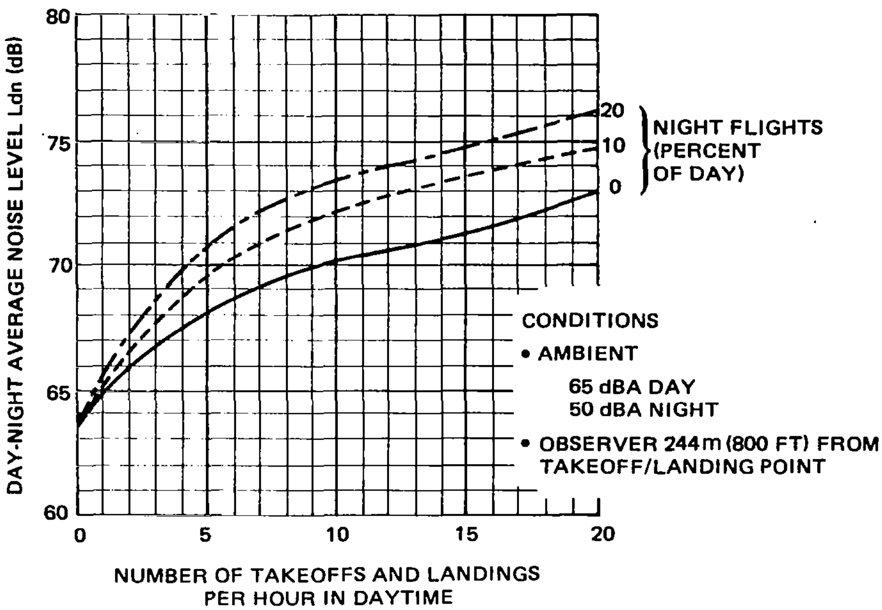

Figure 7.- Light turbine operating noise level.

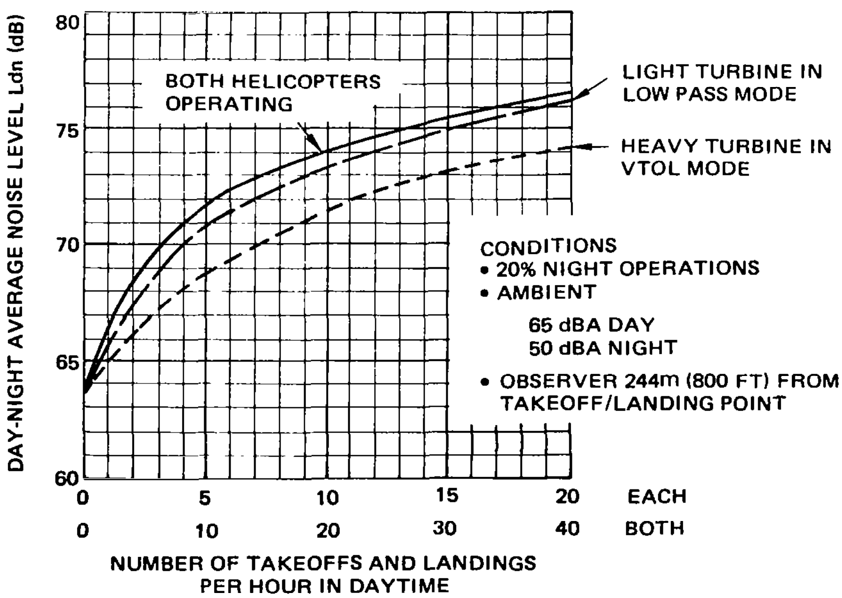

Figure 8.- Light and heavy turbine helicopters operating noise levels.

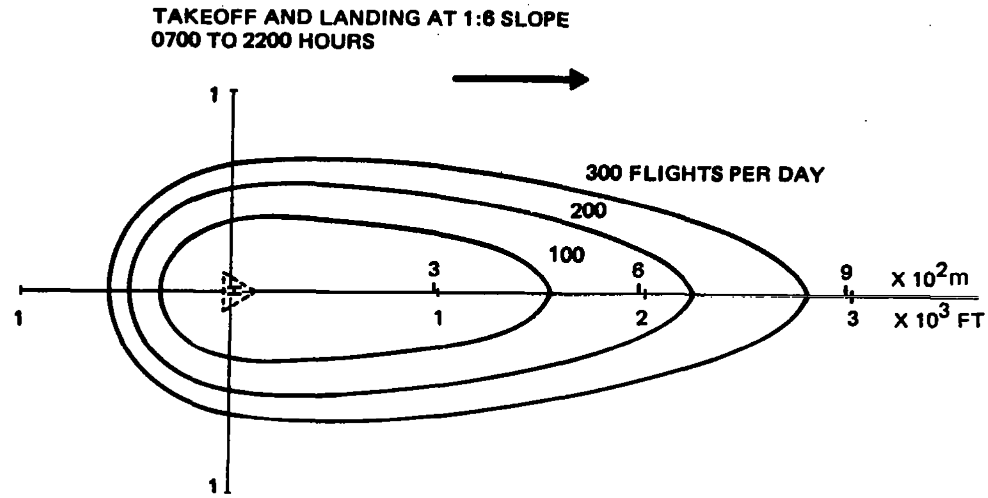

Figure 9.- Noise footprint for a light turbine helicopter.
Ldn = 65 dBA.

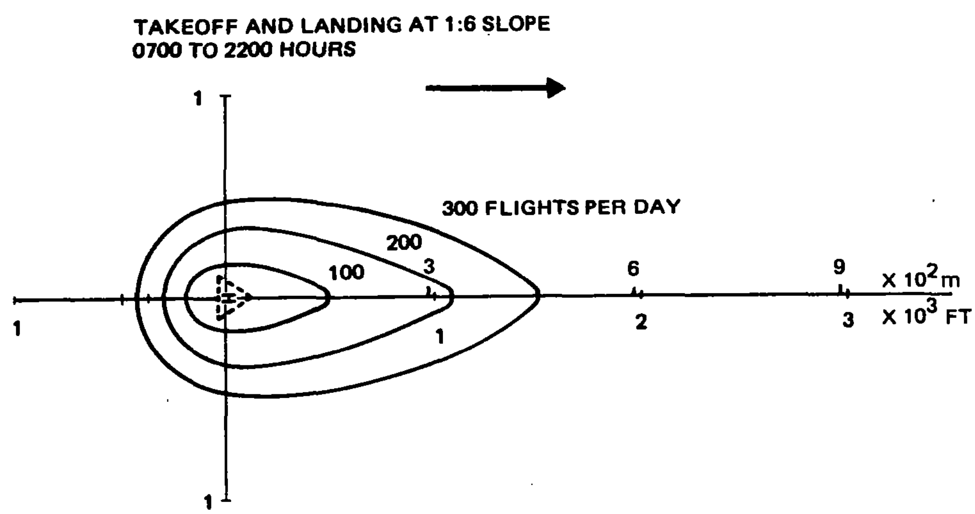

Figure 10.- Noise footprint for a light turbine helicopter.
Ldn = 70 dBA.

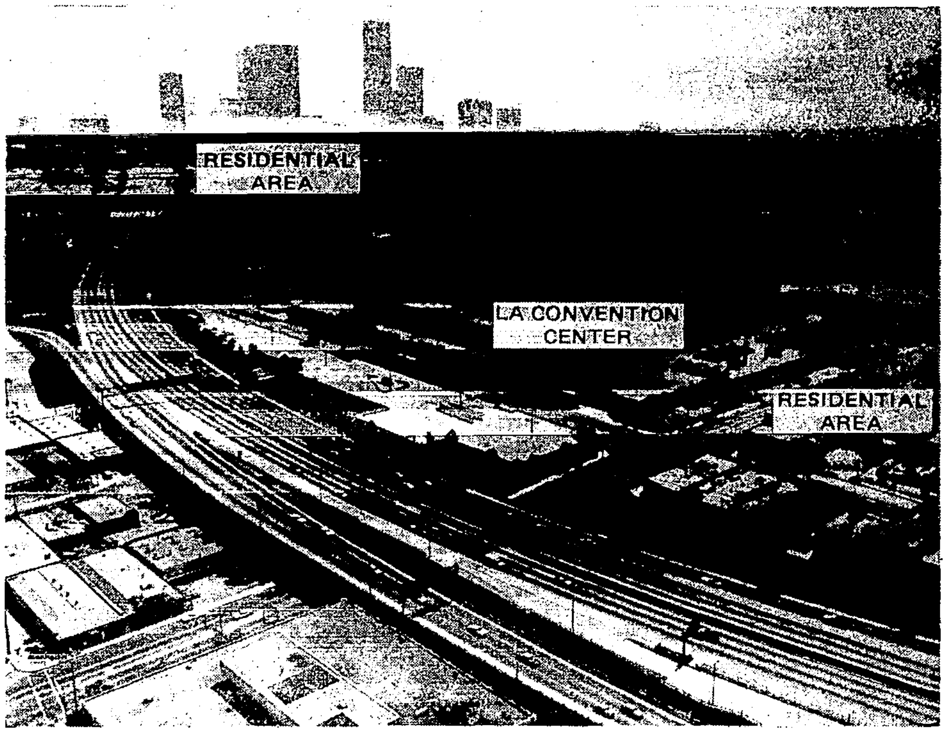

Figure 11.- Proposed Los Angeles public-use heliport.

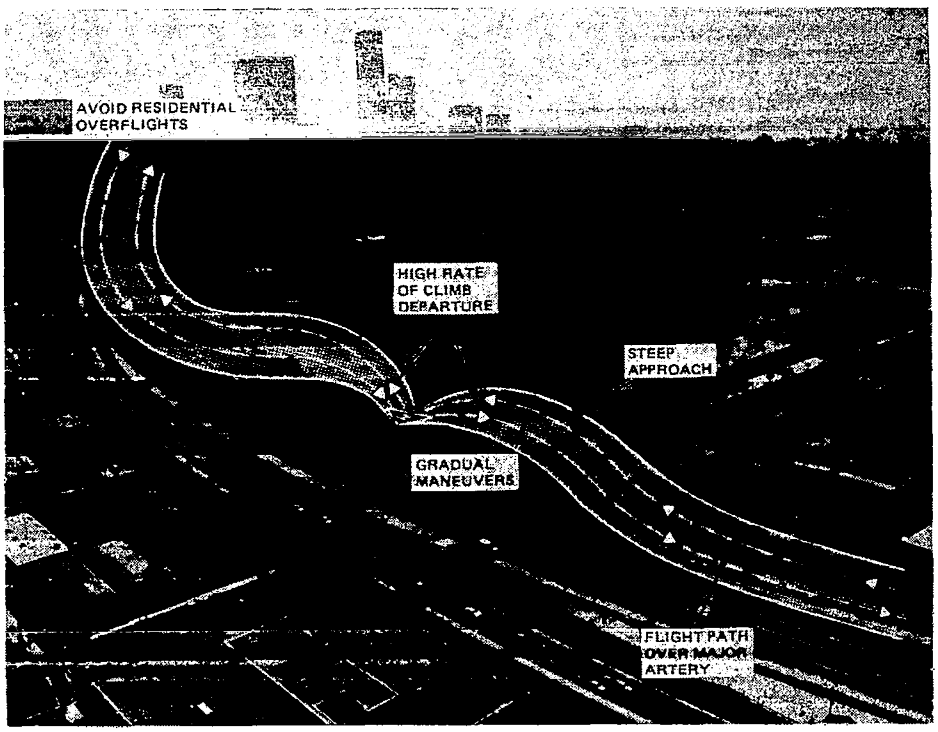

Figure 12.- Noise reduction techniques.

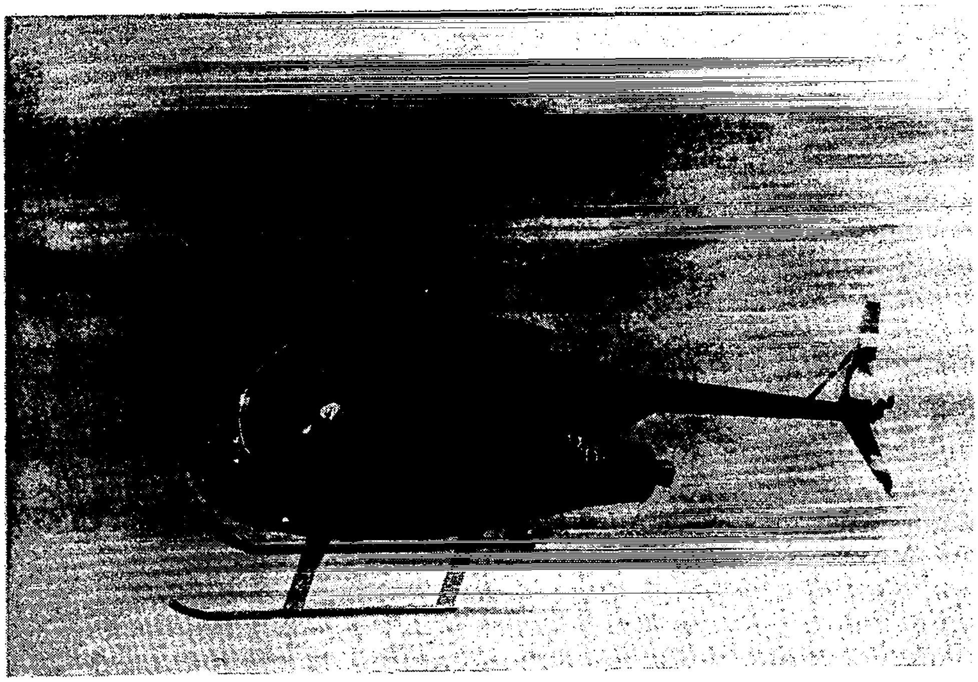

Figure 13.- The quiet one.

Figure 14.- 500D.

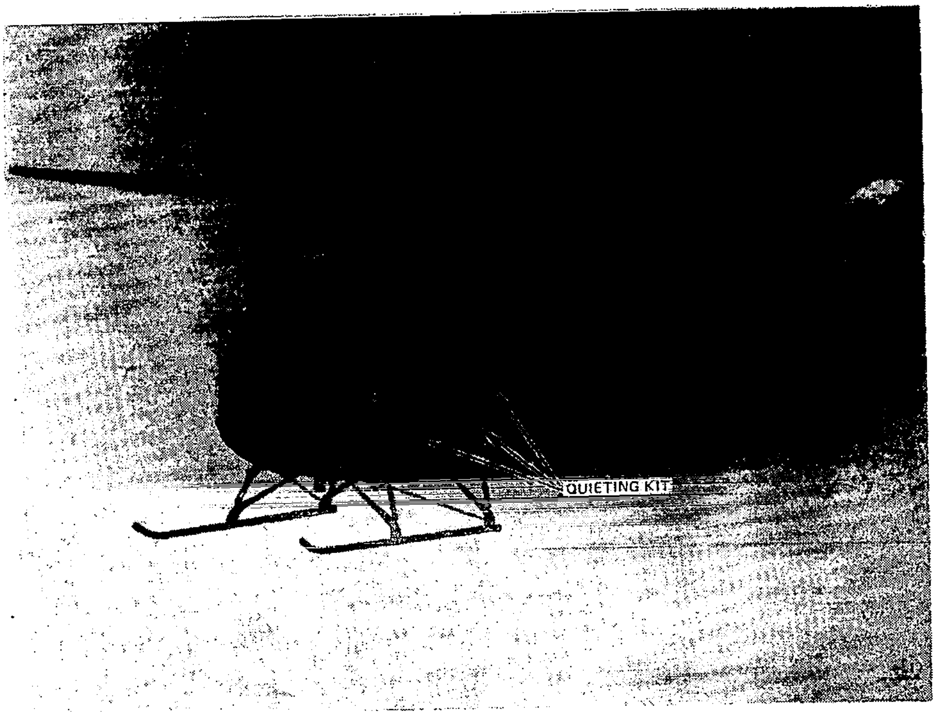

Figure 15.- 300CQ.